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(54) **COVER GLASS ARRANGEMENT FOR AN ELECTRONIC DEVICE**

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CPC H04N 5/2254
USPC 348/335, 374, 375
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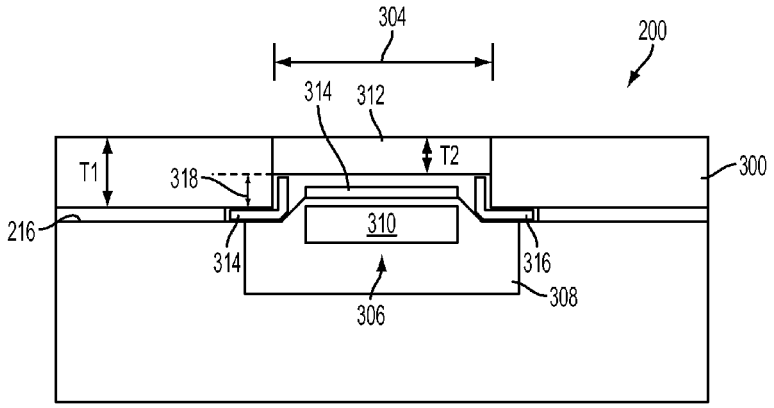
(57) **ABSTRACT**

An electronic device can include a camera and a cover glass arrangement disposed over the camera. The cover glass arrangement includes a thinner region or cover glass that is positioned over a light-receiving region of the camera. Additionally, the thinner region or cover glass can be disposed over the light-receiving region and at least parts of one or more non-light receiving regions of the camera.

17 Claims, 4 Drawing Sheets



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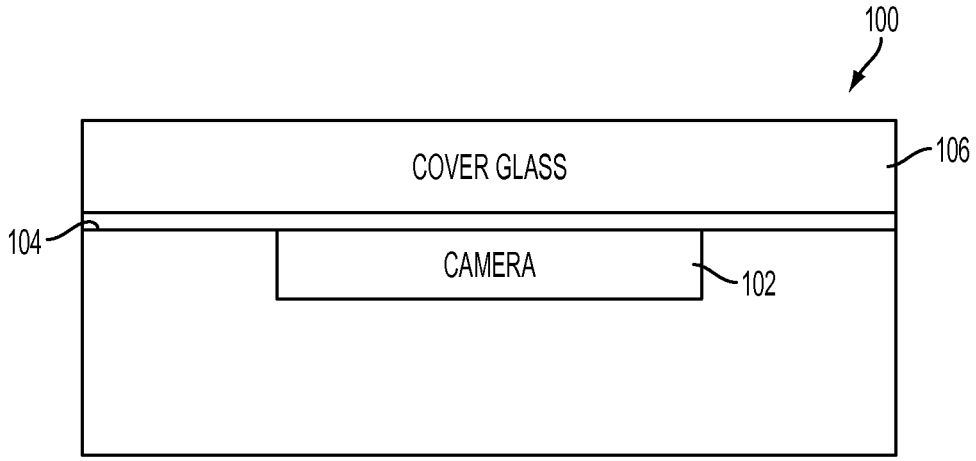


FIG. 1
PRIOR ART

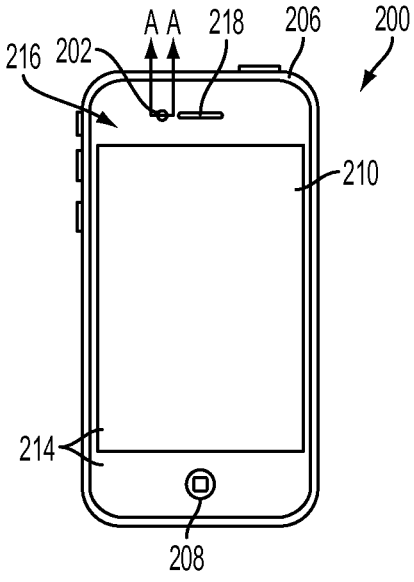


FIG. 2A

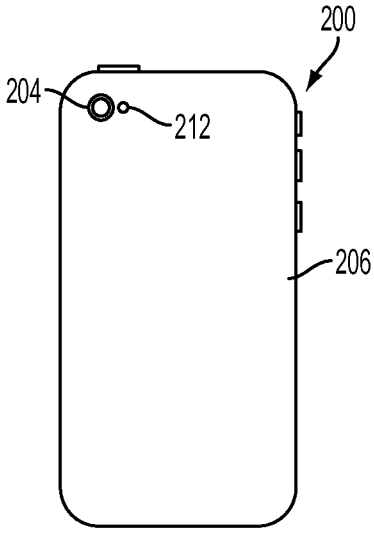


FIG. 2B

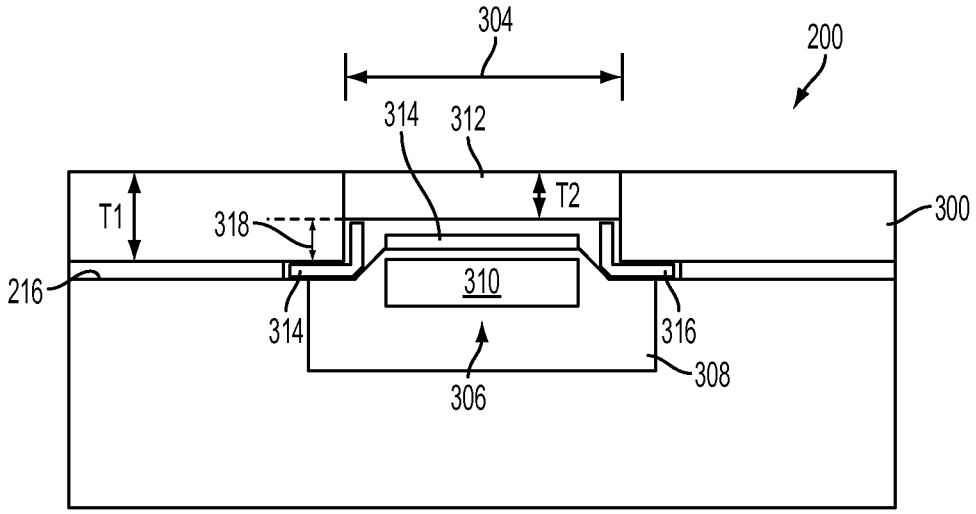
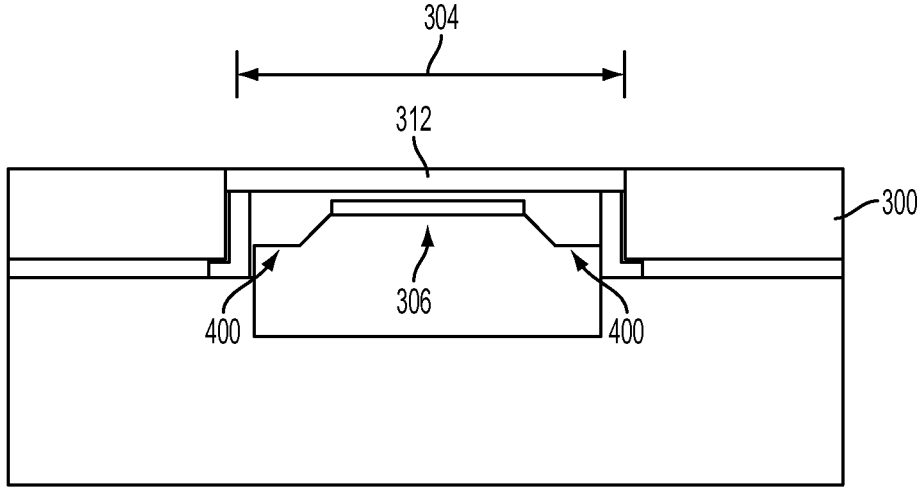

304
200
314
312
T1
T2
318
300
216
310
314
316
308
306

FIG. 3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300
306
400
400

FIG. 4

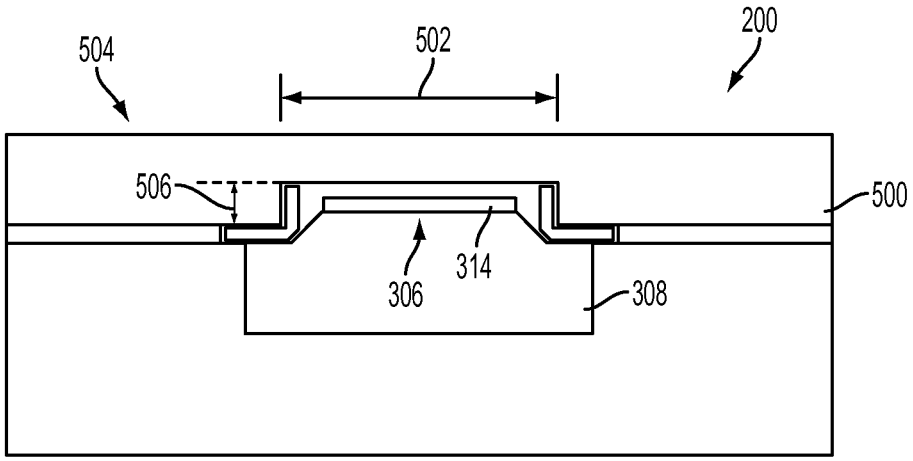
504
502
200
506
500
306
314
308

FIG. 5

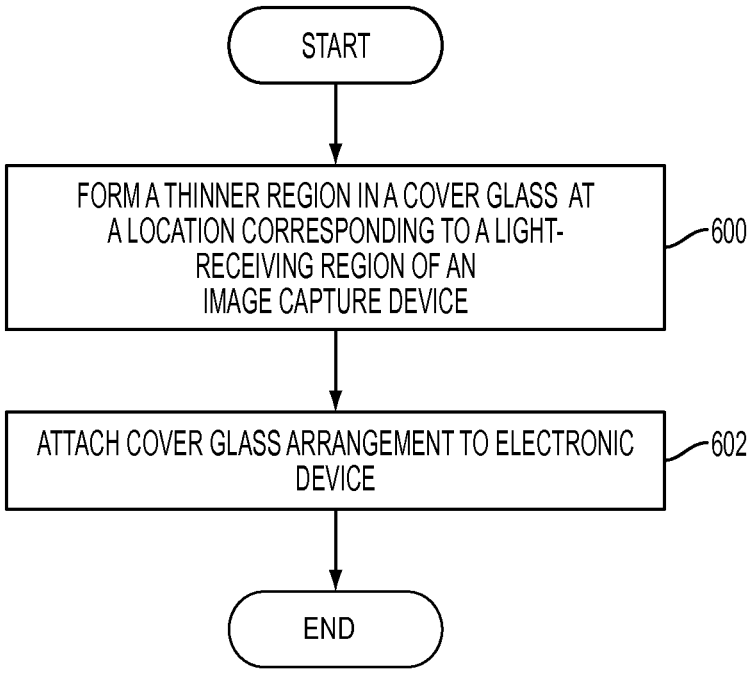
START
FORM A THINNER REGION IN A COVER GLASS AT A LOCATION CORRESPONDING TO A LIGHT-RECEIVING REGION OF AN IMAGE CAPTURE DEVICE
600
ATTACH COVER GLASS ARRANGEMENT TO ELECTRONIC DEVICE
602
END

FIG. 6

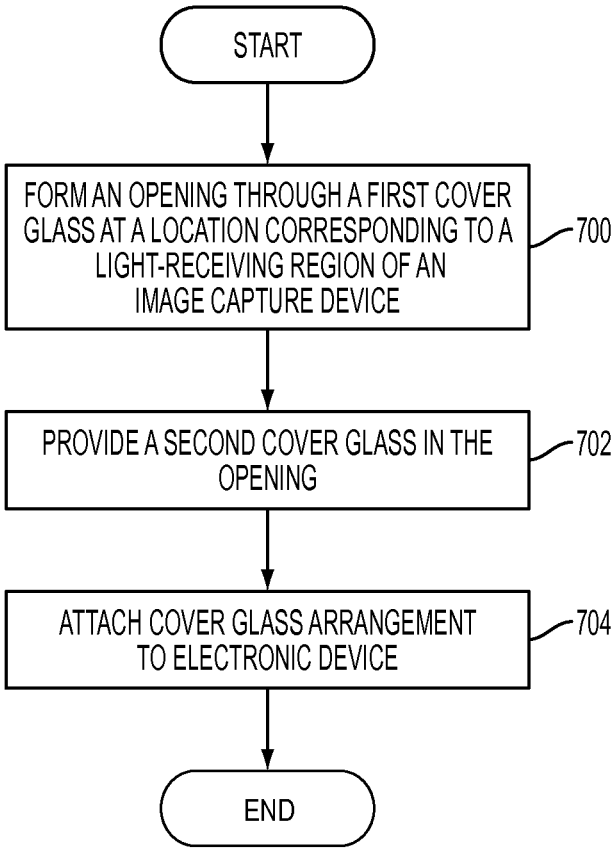
START
FORM AN OPENING THROUGH A FIRST COVER GLASS AT A LOCATION CORRESPONDING TO A LIGHT-RECEIVING REGION OF AN IMAGE CAPTURE DEVICE
700
PROVIDE A SECOND COVER GLASS IN THE OPENING
702
ATTACH COVER GLASS ARRANGEMENT TO ELECTRONIC DEVICE
704
END

FIG. 7

COVER GLASS ARRANGEMENT FOR AN ELECTRONIC DEVICE

TECHNICAL FIELD

The present invention relates generally to electronic devices, and more specifically, to cameras in electronic devices. Still more particularly, the present invention relates to a cover glass arrangement for a camera included in an electronic device.

BACKGROUND

Many electronic devices, such as smart telephones, laptop computers, and tablet computing devices include a camera to capture images and video. FIG. **1** is a cross-sectional view of a prior art electronic device. The electronic device **100** includes a camera **102** positioned adjacent to a surface **104** of the electronic device. The surface can be the front or the back surface of the electronic device **100**. In some devices, a cover glass **106** is disposed over the surface **104** when the camera **102** is positioned adjacent to the front surface of the electronic device **100**. The cover glass **106** can provide various functions or features for the electronic device. For example, in some embodiments, the cover glass **106** can be a touchscreen and provide an aperture for a speaker and microphone.

In some embodiments, the cover glass **106** can constrain the amount of space that is available to the camera **102**. As a result, the functionality of the camera can be limited. For example, a flash module may not be included in the electronic device, or the camera may not include an autofocus feature or a high quality lens.

SUMMARY

In one aspect, an electronic device can include a camera and a first cover glass disposed over the camera. An opening can be formed through the first cover glass over a light-receiving region of the camera. A second cover glass can be positioned in the opening over the light-receiving region of the camera. A thickness of the second cover glass is less than a thickness of the first cover glass. In some embodiments, the second cover glass is a lens for the camera.

In another aspect, an electronic device can include a camera and a monolithic cover glass disposed over the camera. The cover glass includes a thinner region that is positioned over a light-receiving region of the camera. The thinner region can act as a lens for the camera.

In yet another aspect, a method for producing an electronic device can include providing a first cover glass having an opening formed through the first cover glass, and providing a second cover glass in the opening. A location of the opening corresponds to a light-receiving region of a camera. A thickness of the second cover glass is less than a thickness of the first cover glass.

In another aspect, a method for providing an electronic device can include providing a camera in the electronic device, and providing a monolithic cover glass over the camera. The cover glass includes a thinner region that is positioned over a light-receiving region of the camera.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention are better understood with reference to the following drawings. The elements of the drawings are not necessarily to scale relative to each other.

Identical reference numerals have been used, where possible, to designate identical features that are common to the figures.

FIG. **1** is a cross-sectional view of a prior art electronic device;

FIG. **2**A illustrates a front perspective view of one example of an electronic device that includes one or more cameras;

FIG. **2**B depicts a rear perspective view of the electronic device **200** shown in FIG. **2**A;

FIGS. **3-5** are simplified cross-section views of examples of the electronic device **200** taken along line A-A in FIG. **2**A;

FIG. **6** is a flowchart of a method for producing the cover glass arrangement shown in FIG. **5**; and

FIG. **7** is a flowchart of a method for producing the cover glass arrangement shown in FIGS. **3-4**.

DETAILED DESCRIPTION

Embodiments described herein provide a cover glass arrangement for an electronic device that includes one or more cameras. The cover glass arrangement can include a first cover glass and a second cover glass, where the second cover glass is positioned in an opening formed through the first cover glass. In one embodiment, the second cover glass can be disposed over a light-receiving region of a camera. In another embodiment, the second cover glass is positioned over the light-receiving region and at least part of one or more non-light receiving regions of the camera.

The second cover glass can have a thickness that is less than the thickness of the first cover glass. The thinner second cover glass can provide additional space for the camera and/or for an optional lens. In some embodiments, a higher quality camera can be included in an electronic device when the additional space is provided by the thinner second cover glass. For example, a higher quality camera can include a larger sensor, higher quality lenses, an autofocus feature, and/or a flash module.

In another embodiment, the cover glass arrangement can include a monolithic cover glass that includes a thinner region formed in the cover glass. The thinner region can be disposed over the light-receiving region, or over the light-receiving region and at least part of one or more non-light receiving regions of the camera. Like the second cover glass, the thinner region can provide additional space for the camera and/or for an optional lens.

Referring now to FIGS. **2**A-**2**B, there are shown front and rear perspective views of one example of an electronic device that can include one or more cameras. The electronic device **200** includes a first camera **202**, a second camera **204**, an enclosure **206**, a display **210**, an input/output (I/O) member **208**, and an optional flash **212** or light source for the camera or cameras. The electronic device **200** can also include one or more internal components (not shown) typical of a computing or electronic device, such as, for example, one or more processors, memory components, network interfaces, and so on.

In the illustrated embodiment, a cover glass **214** is disposed over the front surface **216** of the electronic device **200**. The cover glass **214** can be made of any suitable material, including, but not limited to, glass, plastic, acrylic, sapphire, and various combinations thereof. One or more portions of the cover glass **214** can be an input region for a touch sensing device and/or a force sensing device. The cover glass **214** can include one or more apertures, such as an aperture for a speaker and/or a microphone **218** and the I/O member **208**. In the illustrated embodiment, the cover glass **214** is positioned over the entire front surface **216** of the electronic device. Thus, the cover glass **214** is disposed over the display, the first camera **202**, and the enclosure **206**. In other embodiments, the

cover glass **214** can be disposed over one or more portions of a surface or surfaces of the electronic device.

As shown in FIGS. **2A-2B**, the electronic device **200** is implemented as a smart telephone. Other embodiments, however, are not limited to this type of electronic device. Other types of computing or electronic devices can include one or more cameras, examples of which include a netbook or laptop computer, a tablet computing device, a wearable computing or display device such as a watch or glasses, a digital camera, a printer, a scanner, a video recorder, and a copier.

The enclosure **206** can form an outer surface or partial outer surface and protective case for the internal components of the electronic device **200**, and may at least partially surround the display **210**. The enclosure **206** can be formed of one or more components operably connected together, such as a front piece and a back piece. Alternatively, the enclosure **206** can be formed of a single piece operably connected to the display **210**.

The I/O member **208** can be implemented with any type of input or output member. By way of example only, the I/O member **208** can be a switch, a button, a capacitive sensor, or other input mechanism. The I/O member **208** allows a user to interact with the electronic device **200**. For example, the I/O member **208** may be a button or switch to alter the volume, return to a home screen, and the like. The electronic device can include one or more input members or output members, and each member can have a single I/O function or multiple I/O functions.

The display **210** can be operably or communicatively connected to the electronic device **200**. The display **210** can be implemented with any type of suitable display, such as a retina display or an active matrix color liquid crystal display. The display **210** can provide a visual output for the electronic device **200** or function to receive user inputs to the electronic device. For example, the display **210** can be a multi-touch capacitive sensing touchscreen that can detect one or more user touch and/or force inputs.

FIGS. **3-5** are simplified cross-sectional views of examples of the electronic device **200** taken along line A-A in FIG. **2A**. As shown in FIG. **3**, a first cover glass **300** is disposed over the surface **216** of the electronic device **200**. The first cover glass **300** has a thickness T**1**. An opening **304** can be formed through the first cover glass **300** around the light-receiving region **306** of a camera **308**. In some embodiments, the light-receiving region of the camera is associated with one or more image sensors **310** included in the camera.

A second cover glass **312** can be disposed in the opening **304**. The second cover glass **312** has a thickness T**2**, and T**2** is less than T**1**. The thinner second cover glass **312** can be made of any suitable material, including, but not limited to, sapphire, glass, acrylic, plastic, and various combination thereof. In some embodiments, the second cover glass **312** is a first lens in optical communication with the camera **308**. Additionally or alternatively, a second lens **314** can be positioned between the second cover glass **312** and the camera **308**. The second lens **314** can be formed with one or more lenses that each have any given shape and dimensions. Example shapes include, but are not limited to, circular, lozenge, or triangular.

The second cover glass **312** can attach to one or more brackets **316**. The bracket or brackets **316** can have any given configuration and size, and can be positioned at any location. Additionally or alternatively, the second cover glass **312** can be attached to a frame (not shown) that attaches to the first cover glass **300**. Any suitable attachment mechanism can be used to attach the second cover glass **312** to the bracket(s) **316** and/or to the frame. By way of example only, an adhesive material and/or a fastener can be used to attach the second cover glass **312** to the bracket(s) **316** and/or to the frame.

The opening **304** and the thinner second cover glass **312** provides additional space **318** for the camera **308** and/or the optional second lens **314**. In some embodiments, a higher quality camera can be included in the electronic device **200** when the additional space **318** is present. For example, a higher quality camera can include a larger sensor, higher quality lenses, an autofocus feature, and/or a flash module. In some embodiments, a front-facing camera (e.g., camera **202**) can be of equal or near-equal quality as a rear-facing camera (e.g., camera **204**).

The embodiment shown in FIG. **4** is similar to the embodiment shown in FIG. **3** except that the opening **304** in the first cover glass **300** is larger. The second cover glass **312** is disposed over the light-receiving region **306** and at least part of one or more non-light receiving regions **400** of the camera.

The cross-sectional view in FIG. **5** includes a monolithic cover glass **500**. The cover glass **500** has a region **502** that is thinner than other areas **504** of the cover glass **500**. Region **502** can have any given shape and dimensions. The thinner region **502** can be disposed over the light-receiving region **306** of the camera **308**. Additionally, the thinner region **502** can have a size and/or shape that positions the thinner region over some or all of the non-light receiving regions of the camera **308**. Like the first and second cover glasses **300** and **312**, the cover glass **500** can be made of any suitable material such as sapphire, glass, plastic, and various combinations of materials.

In some embodiments, the thinner region **502** can be shaped such that the thinner region acts as a lens. The lens can be in optical communication with the light-receiving region **306** of the camera **308**. Additionally or alternatively, the second lens **314** can be positioned between the cover glass **500** and the camera **308**. The thinner region **502** provides additional space **506** for the camera **308** and/or the optional second lens **314**.

FIG. **6** is a flowchart of a method for producing the cover glass arrangement shown in FIG. **5**. Initially, a thinner region can be formed in a monolithic cover glass, as shown in block **600**. The thinner region can be formed with any known cutting, shaping, or trimming process. The location of the thinner region can correspond to a light-receiving region of a camera, or to the light-receiving region and at least a part of one or more non-light receiving regions of the camera.

Next, as shown in block **602**, the cover glass arrangement can be attached to the electronic device. As described earlier, any suitable attachment mechanism can be used to connect the cover glass arrangement to the electronic device. For example, an adhesive material and/or a fastener can attach the cover glass arrangement to the electronic device.

FIG. **7** is a flowchart of a method for producing the cover glass arrangement shown in FIGS. **3-4**. Initially, an opening can be formed through a first cover glass (block **700**). The opening can be formed using any suitable process. For example, the opening can be formed through the first cover glass by etching or grinding the first cover glass. The location of the opening can correspond to the light-receiving region of a camera, or to the light-receiving region and at least a part of one or more non-light receiving regions of the camera.

A second cover glass can then be positioned in the opening, as shown in block **702**. The thickness of the second cover glass is less than the thickness of the first cover glass. The cover glass arrangement can then be attached to the electronic device. In one embodiment, the first cover glass is affixed to a frame in the electronic device. The second cover glass can

be attached to the first cover glass, to one or more brackets, and/or to the frame attached to the first cover glass.

Various embodiments have been described in detail with particular reference to certain features thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the disclosure. And even though specific embodiments have been described herein, it should be noted that the application is not limited to these embodiments. In particular, any features described with respect to one embodiment may also be used in other embodiments, where compatible. Likewise, the features of the different embodiments may be exchanged, where compatible. For example, although the embodiments shown in FIGS. **3-5** depict the front-facing first camera **202** (FIG. **2**), those skilled in the art will recognize that the invention can be used with the rear-facing second camera **404**. Additionally, a cover glass arrangement can include multiple openings with a second cover glass positioned in each opening, or multiple thinner regions formed in a cover glass. Additionally or alternatively, a cover glass arrangement can include both one or more openings with a second cover glass positioned in each opening and one or more thinner regions.

What is claimed is:

1. An electronic device, comprising:

a camera;

a first cover glass disposed over the camera;

an opening formed through the first cover glass over a light-receiving region of the camera; and

a second cover glass positioned in the opening over the light-receiving region of the camera, wherein a thickness of the second cover glass is less than a thickness of the first cover glass.

2. The electronic device as in claim **1**, wherein the second cover glass comprises sapphire.

3. The electronic device as in claim **1**, wherein the second cover glass comprises a lens in optical communication with the light-receiving region of the camera.

4. The electronic device as in claim **1**, wherein the electronic device comprises a smart telephone.

5. An electronic device, comprising:

a camera; and

a monolithic cover glass disposed over the camera, wherein:

the cover glass includes a first region that forms an outer surface of the electronic device, and a second region over a light-receiving region of the camera; and

the second region is thinner than the first region.

6. The electronic device as in claim **5**, wherein the cover glass comprises sapphire.

7. The electronic device as in claim **5**, wherein the second region comprises a lens in optical communication with the light-receiving region of the camera.

8. The electronic device as in claim **5**, wherein the electronic device comprises a smart telephone.

9. A method for producing an electronic device, comprising:

providing a first cover glass having an opening formed through the first cover glass, wherein a location of the opening corresponds to a light-receiving region of a camera; and

disposing a second cover glass in the opening, wherein a thickness of the second cover glass is less than a thickness of the first cover glass.

10. The method as in claim **9**, further comprising disposing a camera in the electronic device.

11. The method as in claim **9**, further comprising attaching the first and second cover glasses to the electronic device.

12. The method as in claim **9**, wherein disposing the second cover glass in the opening comprises disposing a sapphire cover glass in the opening.

13. The method as in claim **9**, wherein disposing the second cover glass in the opening comprises disposing a lens in the opening such that the lens can be in optical communication with the light-receiving region of the camera.

14. A method for producing an electronic device, the method comprising:

disposing a camera in the electronic device; and

disposing a monolithic cover glass over the camera, wherein:

the cover glass includes a first region that forms an outer surface of the electronic device, and a second region over a light-receiving region of the camera; and

the second region is thinner than the first region.

15. The method as in claim **14**, wherein disposing the monolithic cover glass over the camera comprises disposing a monolithic cover glass over a surface of the electronic device.

16. The method as in claim **14**, wherein disposing the monolithic cover glass over the camera comprises disposing a monolithic sapphire cover glass over the camera.

17. The method as in claim **14**, wherein the second region over the light-receiving region of the camera comprises a lens in optical communication with the light-receiving region of the camera.

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